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OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

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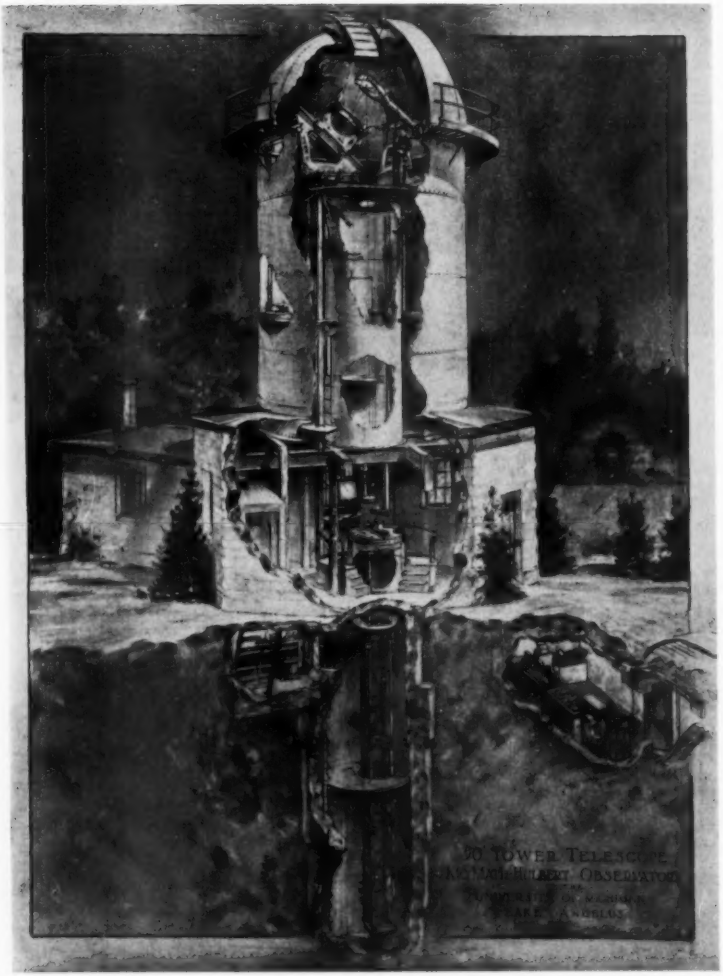
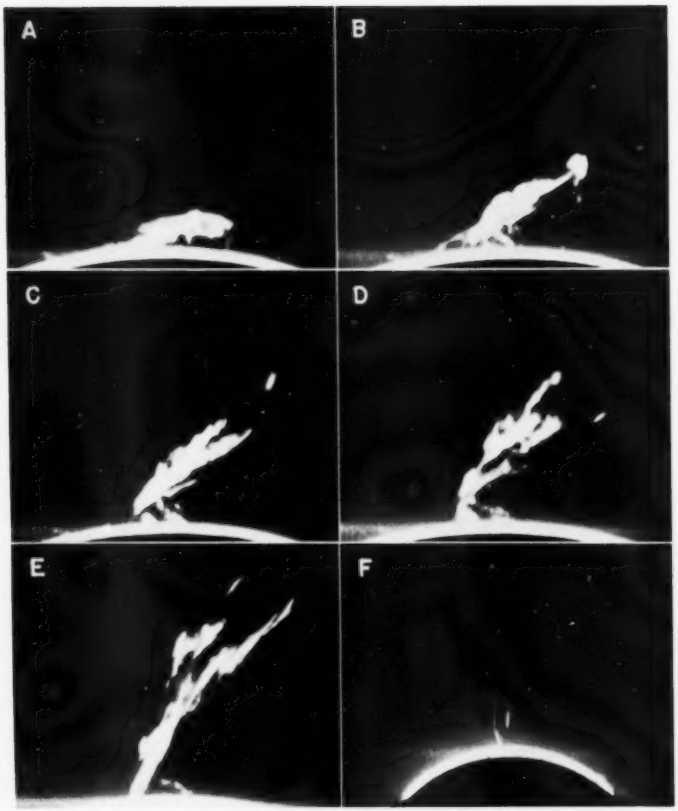


Cut-away View of the New Tower Telescope of the McMath-Hulbert Observatory.

PLATE II



Great Eruptive Prominence of September 17, 1937, photographed in the K line of calcium at the McMath-Hulbert Observatory. Exposures made at the following G.C.T.

A, $14^h\ 50^m.69$; B, $14^h\ 55^m.84$; C, $15^h\ 06^m.13$; D, $15^h\ 09^m.11$; E, $15^h\ 14^m.31$; F, $16^h\ 06^m.7$.

Exposures A to E with 20-foot focus mirror, F with lens of 74 inches focal length. In F prominence extends 1,000,000 km. above the sun.

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CELESTIAL KINEMATOGRAPHY*

By R. M. PETRIE

(with Plates I and II)

THIS paper provides a survey of the recent and fascinating application of motion-picture photography to astronomical objects and problems. In the rapidly-advancing march of science, novel expedients and applications occur frequently and astronomy is not without its share. The work to be described is an excellent example of this tendency and is one which has enriched the educational aspects of our science as well as contributing to its ever increasing fund of knowledge. This discussion will be limited to the work of the McMath-Hulbert Observatory of the University of Michigan† because that institution has rapidly assumed leadership in celestial kinematography and because of the writer's familiarity with its development.

Early studies in using motion-picture cameras directly attached to a telescope were begun in 1927 when the late Francis C. McMath of Detroit, Michigan, erected a four-inch refractor to which was attached a small spring-driven camera. With this equipment Dr. R. R. McMath made some experimental films with the moon as subject, and these experiments led to the building, in 1928 and 1929, of the McMath-Hulbert Observatory at Lake Angelus, Michigan. This was

*A lecture before the Victoria Centre, October 5, 1938.

†For a more complete description of this observatory and its work the reader should consult the *Publications of the Observatory of the University of Michigan*, Vol. 4, No. 4, 1931 and subsequent numbers.

subsequently deeded to the University of Michigan. Originally the observatory possessed a 10½-inch Cassegrainian reflector of 15 feet focal length and a Bell and Howell 35 mm. motion-picture camera, with the spring drive replaced by a motor-driven shutter and film release. Additional secondary mirrors were secured later resulting in equivalent focal lengths for the telescope of 45 and 71 feet. With this equipment excellent motion pictures of various celestial objects have been made including shadow changes in lunar craters, the rotation of the planet Jupiter as evinced by the changing cloud belts, the motions of Jupiter's satellites as they circle about the planet, and the beautiful phenomenon of a star being occulted by the moon. In 1932 an expedition to Fryeburg, Maine, resulted in a successful and dramatic motion-picture film of a total solar eclipse. These pictures show the gradual obscuration of the sun's disk, the beautiful "diamond ring" and "Bailey's beads" effects, the solar prominences projecting from the limb, and the sudden appearance of the corona at the instant of totality.

Part of the original plan of the founders was to study solar phenomena through the medium of motion-pictures since the rapidly changing surface of our luminary renders it a particularly suitable subject for such photography. In 1932 this project was begun with the construction of a highly-specialized instrument, rejoicing in the name *spectroheliokinematograph*,[1] attached at the Cassegrainian focus of the reflecting telescope. This instrument was designed to secure motion-pictures of solar prominences, sun-spots and flocculi using only the light of that very abundant element, hydrogen. The results were so promising that plans for a more powerful and efficient solar instrument were made, culminating in 1936 in the construction of a large solar tower and spectroheliograph in conjunction with a motion-picture camera of high precision.[2] The solar telescope has produced many beautiful and remarkable solar films of great value to educator and research worker. Astonishing solar activity and new phenomena have been revealed for the first time and it is quite clear that advances in solar physics will be made as a result of the McMath-Hulbert

[1] *P. Univ. Mich. O., V*, 103, 1933.
[2] *P. Univ. Mich. O., VII*, 1, 1937.

films. Thus, in a decade, the various problems involved in the application of the motion-picture camera to astronomy have been solved and results of educational and scientific value obtained.

In closing this brief historical sketch, it will be of interest to members of this Society to note that these advances have come about through the work of amateur astronomers. The founders of the observatory, the late Francis C. McMath, the director, Robert R. McMath, and Henry S. Hulbert, all of Detroit, are added to the long list of zealous and devoted non-professional astronomers who have illumined the annals of our science. Their success will be an inspiration to hundreds of amateur astronomers in our membership who labour patiently and enthusiastically in the science they love.

Astronomy lends itself readily to description by the motion-picture method and the original main purpose in making astronomical "movies" was to aid the field of visual education. Astronomy is to a large degree a dynamical science; the measurements, calculations and theories have, to a great extent, to do with the kinetic qualities of the universe, such as motions, orbital studies, attractions. We study the movements of the earth and its satellite, of the planets, the stars, and even galaxies. It is difficult for the student, limited often to a few brief glimpses through a telescope, to appreciate this kinematical aspect of astronomy. Numerical examples are often sterile and the teacher must resort to a series of "still" photographs, generally with a somewhat unsatisfactory result. Kinematography of the sky offers, therefore, a new and powerful weapon in the dissemination of astronomical knowledge.

As the quality of astronomical motion pictures improved, and the technique became standardized, there emerged the realization that here was a valuable research tool. The advantage of the method is that it allows of a great number of photographs to be made in rapid succession with accurately known time intervals, and under identical optical conditions. Any ephemeral phenomenon or any problem requiring rapid and numerous observations can best be treated in this way. Examples are discussed later.

The special problems of technique to be solved arise chiefly from the fact that the final projected picture is magnified to such an extent

that ordinary tolerances in guiding, flexure, focussing, etc., are inadmissable. Accurate focus is made possible by the use of a microscope so mounted that its focal plane is interchangeable (optically) with the plane of the film. Powers of several thousand are used and while such magnification is too large for ordinary purposes it enables one to focus the camera with certainty. The design of the telescope and guiding telescope was carefully studied from the standpoint of minimizing flexure which has been eliminated to a great extent.

The principal mechanical problem arises in driving the telescope. Due to the great focal-length and subsequent high magnification, the telescope must follow accurately the apparent motion of the object being photographed in order that guiding be unnecessary during exposure. It must be emphasized that a *following* rather than a *guided* telescope is required. If the instrument does not follow the object accurately in its apparent motion in right ascension and declination so that guiding is required during exposure, or even in large amounts between separate exposures, a blurred image results, fatal alike to research and visual education. Contrary to popular conception it is not sufficient to correct only for the earth's rotational motion as reflected in the diurnal motion of the heavens. Atmospheric refraction, the motion of the object itself, and (in the case of the moon) geocentric parallax conspire to produce an apparent motion that may differ considerably from the sidereal rate and be appreciable in declination. A calculation for the moon, on October 3, 1934, at 4.30 a.m., for the position of Lake Angelus shows that its orbital motion was 29″ per minute eastward and its apparent motion due to refraction and parallax was 4″ per minute also eastward; at the same time the apparent motion in declination was 8″ per minute northward. This means that the telescope for that observation had to move westward at the sidereal rate diminished by 33″ per minute and in addition a northward motion of 8″ had to be supplied, and since the exposure time for this example was 15 seconds one can see that failure to supply these motions would have resulted in an image lacking in sharpness. A further complication arises because these motions are constantly varying so that flexible drives are necessary. That these requirements have been successfully met, through the ingenuity of Director McMath, is attested by the motion pictures of

lunar craters which sometimes require exposures carried on throughout a night with large variations in the moon's apparent motion during the interval.

The type of device evolved, with its great accuracy and flexibility, is an outstanding contribution to telescope design, especially where accurate photography is contemplated. Its superiority over the conventional "driving-clock" is so marked that it has been adopted for several large telescopes and is under consideration for other proposed instruments.

The contribution of these films in education and popularizing astronomy need not be discussed further here.* It remains to consider briefly one or two scientific applications. First, let us mention the study of lunar topography.[3] The heights of lunar mountains and crater walls have been derived from their shadows upon the lunar surface since the studies of Galileo and Wm. Herschel (a summary of the methods is given by Goodacre, *The Moon*, 1931, page 361). The height of a formation derived from a measured shadow length, however, refers to its elevation above the surface of an ideal, a spherical, moon. Such determinations, while valuable, give different values when made at different phases because of the roughness of the lunar surface; and furthermore they tell us little regarding the topography near the object being measured. By means of a long series of exposures of short duration upon motion picture film, it has been possible to study the changing shadow lengths during the terrestrial night and to explore the "terrain" near mountain and crater wall and to derive the actual shape of the lunar surface over which the shadow passed. Such work, when greatly extended, will give a true idea of the actual lunar surface and a proper level from which to express the heights of formations. So far as the writer is aware this method is the only one capable of supplying a sufficiently detailed description of lunar topography.

Another application which will occur to you is the study of the short-lived solar phenomena; sun-spots, prominences and flocculi,

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*Through the courtesy of Dr. E. Pettit of Mount Wilson Observatory the audience was enabled to study a McMath-Hulbert film of solar prominences.

[3] *P. Univ. Mich. O., VI*, 67, 1935.

solar granulation. The natures of these objects require, for their understanding, that observations be accumulated rapidly and here the motion-picture film is unrivalled. Recent numbers of the *Astrophysical Journal* and the *Publications of the Astronomical Society of the Pacific* contain numerous results derived from studies of solar prominences and their motions. It is easy to predict that a rich field for investigation is now opened to astronomy in these solar film-records.

An account of the work of the McMath-Hulbert Observatory by R. R. McMath, with special reference to solar studies, appeared in *The Scientific Monthly* for November, 1938. In it the reader will find a description of some of the results and problems presented by the new solar telescope and spectroheliograph.

The examples mentioned do not exhaust the possibilities of celestial kinematography, but rather indicate its potentialities. We may, in the future, look forward to applications and discoveries of interest to us all, and of value to astronomy in its continuing progress.

Dominion Astrophysical Observatory,
Victoria, B.C.
December 27, 1938.

CONCERNING SPACE*

By A. T. DeLury†

SOME weeks ago Mr. Collins, your former president, remarked to me that the newer expositions of the larger astronomy took for granted on the part of the reader a familiarity with such concepts as curvature of space, and the four dimensional space with time as the fourth element. After some discussion he proposed a paper for the society, hence this item in the Fall Programme.

In the early stages of human development, observation of objects created or stimulated an interest in certain of their aspects, as their shape, relative size, distance, contour. A necessary language came into being and gradually words as—in our language of to-day—surface, line, point, even *plane* surface, *straight* line, angle came to have a more or less definite association with objects, in a space wherein all things were seen to exist. In course of time specific relations among these lines, triangles and the like came to be surmised and noted and confirmed, as: *Two sides of a triangle are together greater than the third side; a figure with four equal sides and one of its angles right has all of its angles equal, each a right angle.* Thus there grew up a body of reasonably assured knowledge, to the extent indeed that new properties were seen to follow from established facts, without having to await discovery through direct observation. Inevitably—it now seems—there evolved the desire to organize and to enlarge this domain of things known, a momentous advance which culminated in Euclid's Elements, a treatise on geometry and a related arithmetic, and a symbol of a newly achieved idea, that of a scientific *method.* The steps in the organization consisted in definitions of whatever were to be considered as lines, figures and so on, and a formulation of certain fundamental warrants to conclusions, and of certain assumptions or postulates which were to be taken as binding, and then the

*An Address to the Toronto Centre of the Royal Astronomical Society, November 22nd, 1938.

†Dr. A. T. DeLury, Professor-Emeritus of Mathematics at the University of Toronto, was one of the earliest members, is a Fellow, and Past President of the Royal Astronomical Society of Canada.

derivation, on the grounds admitted, of a *corpus* of theorems and constructions.

When it came to the definitions, say the definition of a plane surface or of a straight line, to mention two that will be examined more closely later, difficulties, not new, stood in the way. The line, the plane, the circle, to be defined had no actual objective existence: there is no veritable straight line, no veritable surface; proximate—so to speak—lines and surfaces there are, suggestive to be sure, but this is only to affirm that the surfaces, lines, figures exist in the mind only, are *concepts* having, it is true, their source in things seen or *perceived*. Accordingly the definitions were in the main the assertion of the existence of the things under consideration, the quality of definition residing in the assumptions or postulates regarding them. Thus, in the case of the straight line—there is to be such a thing—the postulate asserts that any other line joining any two of its points, cannot be a straight line.

These postulates, deriving as they do from observation, assured an accord between the ideal science and the relations in the world of the actual. Thus geometry became a basis for all the exact sciences as astronomy, physics, engineering, and there developed the possessing conviction that in the matters with which this science has concern the geometrical fabric is a counterpart, a replica, of the universe,—a conviction which later was to become a brake on advance.

Regard anew the plane and the straight line. The surface of a still pond is—certainly at one time was—a close representation of the plane of the mind. Yet a knowledge of the figure of the earth assures that it is part of a surface practically spherical. The straight line—of the mind—finds a just representation in the direct line on the surface of the pond joining any two of its points. Yet that direct line is an arc of a great circle of the sphere of the earth. The definition of the straight line in the plane is, in a region of the surface of the sphere not relatively great, essentially that of the arc of a great circle on the sphere. For such a region there is a geometry very similar to that of the geometry of the plane, the *straight* line in the two surfaces being the *unique*, let us say the shortest line between any two of its points. Later, geometry on a general surface was to be suggestively developed, the shortest lines between pairs of points being regarded as straight lines.

If in a line, say a straight line, a point be taken as a starting point for measurement, every other point in the line can be designated by a length or by a number denoting a length with an indication as to whether this length is to be carried to the right or left, the line is *one*-dimensional. In a plane there being taken a point and two straight lines, at right angles suppose, through this point, every other point in the plane can be located by means of two lengths or numbers denoting these, namely the two distances of the point from these lines; the plane is *two*-dimensional. In the manner in space there being taken a point and through it three straight lines mutually at right angles, every point in space can be specified by three lengths, or the numbers denoting these, namely, the three distances of the point from the three planes determined by the taken lines; space is *three*-dimensional. Descartes boldly accepted these facts, and shewed that, to its great advantage, geometry could be established by algebra, taking the numbers that designate a point as significant of the point. Thus in a plane if x and y denote the distances of a point, potentially any point, from two straight lines at right angles to each other in the plane, and if x and y were taken so that $x^2+y^2=1$, this equation applies to, covers, comprises, all the points where distance from the intersection of the lines is equal to 1; that is, it completely signifies the circumference of a circle of the radius 1. So in three dimensions $x^2+y^2+z^2=1$ denotes a spherical surface of radius 1. If then without experience of a space of four dimensions, we employ four numbers and write $x^2+y^2+z^2+w^2=1$, and, in adventure, speak of this as a *four*-dimensional figure, say a *four*-sphere, we merely *choose* to enlarge our outlook, to create a new family. In astronomy and dynamics points or particles or bodies changing their places with the passage of time, are located by three space-numbers, x, y, z, and the number t, denotes the time measured from some date, and it is only the recognition of a fact to speak of the field of dynamics as a four-dimensional manifoldness, and to think of "time-space" as a family of four dimensions.

In Euclid's geometry it is shown that, in a plane, a straight line and an external point being given, through the point there is one straight line which, no matter how far prolonged in either direction, will not meet the line. This line is obtained by drawing from the given point a perpendicular to the given line and then

drawing a line at right angles to this perpendicular. Not surprising, but startling on reflection. The admitted fundamental principle on which the science rested was experience, and the field open to experience is not large. Whereas "never meeting" seems to imply what is ordinarily understood as the infinite. A little consideration reveals that this appearance on the scene of the infinite rests back on the postulate that two straight lines can have at most one intersection. On the sphere "straight lines" i.e., the arcs of great circles, for a limited experience meet in one point, yet when prolonged have ever a second intersection, the point on the sphere opposite to the seen point of intersection. Thus the assumption of only one intersection of two straight lines raises the question of the infinite, that is, *conditions* infinity, or determines something probably outside of the range of experience. May it not be that in the very nature of things in the essential character of space, the plane as seen by Euclid does not exist but is required to be somewhat as the sphere-surface, in other words to have what has come to be regarded as curvature. Now, the sphere-surface and the plane are two dimensional, yet they force the question as regards the space of three dimensions. In the two dimensional field the sphere-surface is, *if experience remains within it*, infinite in the sense of having no boundary, and it is possible to go forward in a path, say in a great circle, without encountering hindrance, yet the surface is not infinite in the sense of being large beyond measure. So too the assumption in three dimensions of a property which may be by analogy called curvature, would allow unboundedness to co-exist with finiteness in respect to magnitude. While for three dimensions this may not be envisaged, yet it may be claimed that it comes within the scope of the intellectual imagination. The postulates upon which this conception rests, do not, at least need not, clash with the results of experience, the field for experience being not vast. If then a geometry, a variant from that of Euclid, lends itself better to an explanation of the universe, and removes or modifies the difficulty inherent to an extent of space exceeding measure, there is no logical objection to its invocation.

The two questions raised at the outset have been considered, perhaps clarified, and with this the paper might very well find an end. Yet a few additional words will allow a more artistic finish.

It has been seen that in the geometry of Euclid through a point external to a given line in a plane a straight line can be drawn in the plane so as not to meet this line. It was pointed out that this fact rested on the assumption that two straight lines could have only one point in common. There was also the suggestion that the assumption of a second point of meeting required a geometry like that on the surface of a sphere. Euclid's conclusion was followed by another assumption, virtually that the non-meeting line through the point was the only non-meeting line through this point, and in the plane. From this assumption follows a wealth of results as: that the angle-sum in a triangle is always two right angles, that there is a four-sided figure, sides equal and of any length whatever, with each of its four angles a right angle, that similar figures do exist. The warrant from experience is of the highest, so high as to call for the proof rather than on the assumption that there is only one such line. A distinguished Russian mathematician, Lobachevsky, in the early years of last century gave a new turn to the problem, by assuming that there might be more than one such line through the given point, which implies that all the lines in the plane through this point, fall into two sheaves of lines, one sheaf of lines meeting the given line, the other sheaf not meeting it. He followed this up and reared a geometry, complete and consistent in itself, a logical system available if necessary or even if only promising in the quest that knows not surcease. This non-Euclidean geometry like the Euclidean, demands extent beyond measure, the infinite.

Thus for our space there are three geometries resting on the same base of convictions or on the postulates that evolved from actual or possible—and therefore finite, so to speak,—experience. Three ways opened up, through the raising of the question of the infinite in extent. One, the most direct, led to the normally accepted geometry of Euclid. A second through a slight deviation to the geometry of Lobachevsky. The third to the geometry with the spherical association, which now "has the cry", and, particularly in regard to its development found its major impulse in the profound paper of Riemann on the Hypotheses inherent in the Foundations of Geometry.

University of Toronto,
Toronto, Ontario.

OBSERVING FOR AMATEURS

By Frank S. Hogg

IN earlier times, the members of our Society took a very keen interest in the practical problems of observation, and contributed original observations of value. Throughout more recent times a few enthusiastic amateurs have continued to do really constructive observing, in contrast to mere sporadic looking at the stars for one's own satisfaction. However, for many years most of our members have not contributed to the store of astronomical observations. Part of this lack of observing is due to a feeling that the subject of astronomical knowledge, and professional equipment, have advanced so far that the work of amateurs ceases to be of any value. While for many astronomical programmes elaborate equipment and training are necessary, yet there are several fields in which amateur observers are at present doing important work. It is unfortunate, both for astronomy as a science and for the enthusiasm and interest of the amateur, if systematic amateur programmes cease to be followed.

Amateur observers have long contributed valuable observations of the magnitudes of variable stars, notably through the American Association of Variable Star Observers. Others are conducting regular surveys of selected fields, for the purpose of detecting novae. Only last week an American amateur, Mr. L. C. Peltier, discovered a new comet. Recently our own Society has been encouraging amateurs to undertake definite programmes. As a number of members have built their own telescopes, it is desirable that they have suitable observing work. The great success of some of our members, whose meteor observing has been so ably organized and directed by Dr. Millman, is periodically chronicled in Meteor News. Others of our members are systematically co-operating with the A.A.V.S.O. in the variable star and nova search programmes. Dr. Millman has made accessible to the members full instructions for General Meteor Observing, and for Meteor Photography. It is hoped to publish soon detailed advice and instructions in the fields of variable stars, nova-search, and occultations.

In the meantime, attention is particularly called to a programme described in the following pages, for the observation of the aurora. Members of our Society have long been interested in this phenomenon, as is evidenced by the observations and articles frequently published in the JOURNAL. Dr. Chant, in particular, collected such material for many years. The members are now invited to aid in a carefully organized international campaign, under the auspices of Cornell University and the National Geographic Society, for the study of the aurora in the Western Hemisphere. Maps giving the frequency of auroral occurrence at different places (Haurwitz, this JOURNAL, vol. *30*, p. 400, 1936) show that its occurrence in Canada is much more frequent than in the southern parts of the continent. Thus Canadians, as well as being able to extend the area available for the programme, are favourably situated in that a much larger percentage of their observations should show positive results. A further advantage is that this work can be carried on with no equipment.

Any members who wish to contribute systematic observations to this programme are requested to write to Dr. C. W. Gartlein, Cornell University, Ithaca, New York. Dr. Gartlein will send the prospective observers the record sheets for observing and mailing envelopes. It is hoped to keep a record in the JOURNAL of the contributions of our members.

Another important feature of auroral observations is the photography of unusual displays. Some of our members have contributed such material in the past, and such will always be welcomed in the future. Dr. Gartlein is anxious to secure copies of any photographs the observers may secure.

Richmond Hill, Ontario,
January, 1939.

REQUEST FOR AURORAL OBSERVATIONS

By C. W. Gartlein

THE National Geographic Society and Cornell University are sponsoring a program of research on the Aurora Borealis. This study will include height measurements at Cornell University and Colgate University and spectroscopic intensity and descriptive studies at Cornell. Cooperation of a large number of observers, especially in the Western Hemisphere, is being sought in making visual observations of form, color, and times of changes in form of the aurorae seen. This latter part of the study should lead to further information on geographical distribution and enable better correlation between aurorae and other phenomena (changes in radio transmission, solar disturbances, and magnetic variations). It was thought that amateur and professional astronomers might make these observations easily and without interfering with their regular studies. The magnitude of the present auroral displays, as well as the intensive work being done in related fields, makes the initiation of this study desirable at this time. Three airplane lines will also send in reports which should insure the continuity of observation even in cloudy weather.

Instructions for Cooperating Observers

It is hoped that many observers, especially those located away from city lights, will be able to observe the sky at intervals during each evening. An observation should always be made just after dark. Of course, we would like records throughout the night, but this will only be possible where large groups work together. In many cases the regular duties of operators at electric substations require them to make inspections outdoors at certain hours. They might be willing to make simple records or call you when something unusual occurs. Such cooperation was very willingly given at Ithaca. Even simple or incomplete records are valuable since it is important that we get some observation on each aurora. All other things are secondary.

Since it is difficult adequately to describe auroral displays a special report blank has been prepared on which certain aspects of the auroral displays can be easily described. More complete descriptions may be written on the reverse side of the blank and a reference number or letter inserted in the column provided.

The blank is made up of columns representing the hours of the night and at the right spaces are provided for inserting the times when changes in the form of the aurora occur. These times should be given to the nearest minute. The hour blanks should contain some information for each time of observation. If no aurora was seen the symbol 0 should be inserted as well as a symbol to indicate the cloudiness of the sky. When no observation is made the space should be left blank.

When an aurora is observed each hour space should contain the abbreviations for the forms seen in order of their appearance, a number for the maximum intensity, abbreviations for color and an indication of the cloudiness. These have been listed in the order of their importance.

The name and address of the observer should always be given as well as the month. The first blank should also contain a brief description of the observer's location with details about city lights, smoky atmosphere, etc. The time zone used should be given as well as a statement of the time the observer expects to observe. The blanks should be returned at the end of the month or every three months for southern observers and those who can observe only occasionally. In the latter case the dates on the edge of the blank should be appropriately changed. Those wishing to keep a record for their own use should feel free to use the blanks provided. Postage for one ounce is sufficient for one blank.

Forms of aurorae are given at the end of this paper according to a system developed by Professor Carl Störmer and generally used by auroral observers.

Quiet forms (or not moving forms) are usually the type HA, PS, DS, and G.

Intensity of aurorae may be given by either of two systems. By Roman numerals we would designate a faint aurora as intensity I, about as bright as the Milky Way. Intensity II is medium or about as bright as a thin moonlit cirrus cloud. III means bright, as a moonlit cumulus cloud. IV is brilliant, and gives enough

light to approximate direct moonlight (like aurora of July 29-30, 1938). The other system consists in noting by Arabic numerals the magnitudes of stars just visible through the aurora without optical aid.

Colors of aurorae are usually not brilliant, the most common being a light yellowish-green. Occasionally deep red rays or diffuse surfaces are seen.

Pulsations or *Movement.* Pulses of light sometimes move rapidly up from the horizon causing bands and diffuse surfaces to shine out rhythmically. Often the rays and sharp curves of bands have a slow translational motion. It may be toward either west or east and sometimes the motion is different in adjacent parts of the sky. Observations on pulsations, giving the period and motion may be put on the back of the blank.

Several auroral forms have special importance and should be carefully observed. Whenever a corona or partial corona is seen the location of the centre or point of convergence should be carefully noted with respect to the stars and the time given at least to the minute. This enables calculation of the direction of the entering particles and approximately of the direction of the earth's magnetic field.

Whenever isolated forms occur and remain for some time in one position this position should be given with respect to the stars or altitude and azimuth and also the time. The position of quiet arcs and isolated arcs or bands should also be given especially when high in the sky as on September 27-28, 1938.

Times of changes in form should be noted in the proper space and constitute one of the most important observations.

In making observations care must be used in order not to mistake for a real aurora clouds illuminated by moonlight, by city lights or by an aurora. The spectroscope is a sure guide, the green line 5577 Angstroms being characteristic of the aurora.

Sometimes the moonless night sky is quite bright, though otherwise without aurora. Such nights should be noted in the record as "luminous" or "lum".

It is planned to publish brief reports in *Popular Astronomy* from time to time, though no definite schedule has been made. The scientific results of this investigation, including reprints of

papers to be published, will be made available to those observers who desire them.

Since no thorough study of aurorae as seen in the United States has ever been made, these observations will be doubly important and your cooperation will be gratefully appreciated.

Data on displays seen previously will be especially welcome.

Description of Auroral Forms

The descriptions given below are from the works of Prof. Carl Störmer, Prof. Vegard, and others and follow the terminology developed by Prof. Störmer and generally used in this work. The standard abbreviation precedes the descriptive words and should be used in all tabulations.

G Glow. A faint glow near the horizon, resembling the dawn, usually white or greenish color but sometimes red. This is often the upper part of an arc whose lower border is below the horizon.

HA Homogeneous Arc. The arc is usually diffuse above and sharply defined below. It may be near the horizon or quite isolated high in the sky. Sometimes several parallel arcs occur and may be connected at one end by a sharp curve. The color is usually greenish yellow or nearly white. The arc often gradually climbs up the sky and may later have a very luminous irregular lower border and soon after break into rays (type RA). The arc is usually set almost at right angles to the magnetic meridian. Often only parts of arcs are visible.

HB Homogeneous Band. This band has a more irregular form than the homogeneous arc. It may vary from narrow to very wide. The lower border is often irregular and sharply defined. It may sometimes consist of a segment of approximately semi-circular shape which may move across the sky in the direction of the usual arcs HA. The band may have folds and resemble a large curtain. These usually change into bands with ray structure (type RB). The color is usually bluish white.

PA Pulsating Arc. Arcs, or parts of them, may flash up and disappear rhythmically with a period of 10 to 30 seconds. The color is usually bluish green.

DS Diffuse Surface. A diffuse veil or glow, often over large

parts of the sky. They may resemble clouds and often appear after rays or curtains. The color may range from violet white to an intense red.

PS Pulsating Surface. A diffuse patch or surface which appears and disappears rhythmically. Near the zenith the boundary may be sharper. Often appears with, or as part of, a flaming aurora (type F).

RA Rayed Arc. An arc with ray structure. A quiet homogeneous arc often becomes very luminous and then breaks into rays. The rays may be short or long and may vary in brightness along their length.

RB Rayed Band. A band with ray structure. Resemble the bands type HB but composed of rays. The rays may be close together or scattered along the band. Several parallel bands may appear. Near the magnetic zenith the bands may form a corona.

D Draperies. When bundles of rays become long the band often assumes the form of a curtain or drapery. The lower border is often more luminous. Near the zenith they have a fanlike form or partial corona.

R Rays. Rays resemble searchlight beams in a dusty atmosphere. The rays may appear isolated or in great bundles. They are usually greenish yellow but may be red. Rays often appear with other auroral forms.

C Corona. When rays approach the magnetic zenith they seem to converge to a point because of perspective. The corona may be formed by long or short rays, by bands or by draperies.

F Flaming Aurora. A quick moving form consisting of waves of luminosity moving toward the zenith or of invisible waves which cause parts of arcs, bands or patches to appear and disappear rhythmically. Often appears after strong displays of rays and curtains and is often followed by the formation of a corona.

November 1, 1938,
Rockefeller Hall,
Cornell University,
Ithaca, N.Y.

METEOR NEWS

Observations relating to meteors and meteorites are cordially invited.

A NEW IRON METEORITE FROM KAZAKHSTAN, U.S.S.R.

By Prof. P. L. Dravert

(*Translated into English by Dr. I. S. Astapowitsch*)

I HANDED over to the Academy of Sciences, U.S.S.R., a peculiar iron meteorite from the North Kazakhstan region. According to the information of the Director of the Akmolinsk Museum, Semenov (1937), it fell about ten years ago near the village Novorybinskoye, sank into the ground and was later dug out by local peasants. The village Novorybinskoye, Stalin district, North-Kazakhstan region lies 80 km. north of the town Akmolinsk, $\varphi = 51° 53'$ N, $\lambda = 71° 15'$ E. The exact date of the fall has as yet not been established.

As we know, iron meteorites with an observed fall are a rarity. Out of 20 iron meteorites from U.S.S.R. the fall was witnessed by men in only two cases. These are unique because of their weight and sharpness of detail: hexahedrite Boguslavka Oct. 18th, 1916 (two masses with a common plane of fracture along the cube) and Repeev Khutor, Aug. 6th, 1933, ideally orientated, in the shape of the head of an artillery shell.

The Novorybinsk meteorite is of a shape approaching an octahedron, 4 faces on the back being especially well defined. The frontal projection of the meteorite suffered great damage during its flight and its pyramidal shape is partially destroyed by the breaking off of small fragments and by the presence of several pressure marks on the rounded part. However, two faces of the octahedron are defined well enough.

A very thin crust of reddish-brown colour, passing into darker hues, seems under the magnifying glass to be slag-like with vesicular protuberances. This indicates the melting of the surface layer during a brief moment. Here and there on the sections with damaged crust are seen small incrustations of troylite and little drops of laurencite.

The qualitative analysis of the iron showed the presence of nickel and cobalt. After etching with weak nitric acid there appeared on the polished surface of a little piece the characteristic Widmanstätten figures. Even without chemical action, the meteorite surface shows sharply enough signs of its lamellar structure, the elements of which form a typical octahedral net on the faces of the body, made up of little bars of intercrossing kamacite and strips of tenite.

The original weight of the meteorite was 3,055 g., it is now 2,044.5 g. Little pieces were used to obtain the specific weight, which proved to be 7.725.

The crystalline shape of the meteorite may be accounted for by the fact that the cosmical body entering the earth's atmosphere and travelling with tremendous velocity through the layers of the stratosphere with unequal densities suffered successive fracturing, the splitting occurring along the planes of the octahedral structure. This inherent segregation worked through the whole mass which was thus formed an indivisible unit. The fragment thus formed in the shape of an octahedron lost in the lower part of its path a certain amount of mass (especially at the front surface). This mass became scattered under the excessive pressure of the resistant air, the result being the formation of pressure marks. Simultaneously there occurred a rounding off of the edges of the polyhedron. Finally, in completing the last stage of its gradually slowing down race, the meteorite clothed itself in the region of high atmospheric resistance with a thin crust, common to bodies of this type and similar in composition to iron slag. The peculiarities of the shape of the new Kazakhstan meteorite described here make it probable that this specimen is not single. The fracturing of the mass of cosmic iron has undoubtedly produced plurality of falls. And we are probably right in believing that in the steppe surroundings of the village Novorybinskoye there will be detected later on more masses belonging to this meteorite.

Omsk, November 29th, 1938.

SOME LOST METEORITES OF THE U.S.S.R.

(Asiatic Part)

By Prof. P. L. Dravert

(*Summarized and translated into English by Dr. I. S. Astapowitsch*)

ACCORDING to A. F. Goebel's expression (St. Petersburg, XIX century), meteorites fall often into the hands of those to whom they had better not come at all. Even the meteorites reaching us usually pass through many tribulations. So, for instance, the meteorite Nikolaevka, which fell on July 11, 1935, was thrown away as a useless thing by the peasant who dug it out, and it was a school-boy who picked it up and brought it to the collective farm. The largest part of the meteorite Kuznetzove, which fell on May 25, 1932, was ground into powder after being baked, and was washed in search for gold. Several meteorites—Staroje Pesjanoje, Oct. 2, 1933, were broken in a search for diamonds (V. P. Efimov). The Dorofeevka hexahedrite, found in 1910 by the peasant F. G. Gobusov while ploughing, was carried to a smith to be turned into a ploughshare. The smith found, however, that it could be forged only when cold as is the case with iron meteorites. The only meteorite weighing 6.2 kg. which reached us, Khmelevka (fell on March 1, 1929), was broken by the peasants to get flint and finally served as a press in a vat with sauer-kraut. D. Maljuga says that the old women broke off little pieces from the meteorite Kaptal-Aryk (fell on May 12, 1937) which they ground into powder to drink with water as a tonic for the lungs. A considerable portion of the meteorite Saratov (fell in Sept., 1918) was eaten (it was ground into powder and taken as medicine, or mixed with lard and used as an ointment, and so on).

Below is a list of lost meteorites of the Asiatic part of the U.S.S.R. (Gregorian dates used in all cases).

No. 1. 1585.

Some days before Aug. 15 (the day of the death of the conqueror of Siberia—Ermak, established by G. E. Katanajev) a "large blood-red" stone fell from the

sky in the Tashatkan town on the river Irtysh, now 24 km. SSE. of Tevriz, Tara district, Omsk region. It was examined by Ermak and his companions a few days before the former's death. The description is given in the annals of Semen Remezov, mentioned in the list of the governor of the Enisei province, P. V. Mirovitsch, which was turned over to the Russian academician Miller (1705-1783) and later published in the collection of Siberian annals (edition of the Archeographic Commission, St. Petersburg, 1907).

No. 2. 1634.

In the summer loud thunder was heard during clear weather in Tobolsk. A "cloud" appeared and a stone(?) meteorite broke the wooden cupola of the church of Dmitry Solunsky and fell inside the porch causing some damage (Journal "Siberian Fires", Novosibirsk, 1935, No. 4, 160-164) according to the "Tobolsk annals", published in Tobolsk, 1892.

No. 3. 1881.

Beginning of January. In the Tunkin village (now Tunka, 230 km. SW. from Irkutsk, Burjato-Mongolian A.S.S.R.) there fell a sporadosiderite (to judge by the description) of the size of a fist (K. Neumann, Reports of the Siberian Department of the Russian Geographical Society, Irkutsk, 1872, vol. 2, No. 5, p. 293). The meteorite Tunka of the Vienna museum fell at the same place on March 1, 1824 (N. Shtcheglov, Guide of Discoveries, vol. 3, 1826, No. 5, p. 646, in Russian).

No. 4. 187?.

(Before 1875). Near the village Maslyaki, 32 km. N. of the town Kamen, on river Ob, Western Siberia, a stone fell, boring itself to a great depth into the earth. The fall was witnessed by the inhabitants who took it out. At the surface it was black. It was broken into pieces and used in laying stoves (information from the Director of the Kamen Museum, M. A. Kroukovsky, 1926).

No. 5. 1903.

April 20 or 21, 20^{h}, SW. part of the town Tjumen, Omsk region. The fall of an iron meteorite was observed accompanied by detonations and optical phenomena. It was covered by a thin black crust, weighed about ¾ kg., and was of irregular, roughly polyhedral shape, with one convex and another flat face. It was observed and found by Beljankin, Rossomakhin and Rytchkov. N. I. Slovtzov, the owner of a small collection of meteorites, qualified it as a meteorite. Till 1928 it was in the Turin Museum and after the closing of the latter it was lost.

No. 6. 1908.

June 30, 7^{h}. Between the rivers Khoushmo and Kimtchon, Krasnojarks region, Evenk National district, fell the large Siberian meteorite. The Evenks (Tungus) found pieces of metal, resembling iron by their colour and weight (L. Kulik "Mirovedenie", 1933, No. 2 and others).

No. 7. End of 1910.

Or the beginning of 1911, winter. Near the village Khmelevka, 6 km. S., on the Miglev Outchastok, Sedelnikovo, Tara district, Omsk region, the peasan-

S. I. Sidorenko found in summer, 1911, a flat lens-shaped stone meteorite, weighing about 1.6 kg. It had a black and a reddish side. It was found on swampy land and thrown away as useless.

No. 8. Some years prior to 1914.

On the river Yorakh, left tributary of the river Boureya, NW. Priamurye, a piece of iron was found which was supposed to be platinum (N. I. Erassi, see N. K. Vyssotskij, Platinum and the Region of its Extraction, part 5, p. 155, edition of the Ac. of Sc. U.S.S.R., 1933).

No. 9. 1912.

July 12, 9^h, in the village Krestiakh, Vilujsk district, Yakutsk region, a detonating fireball was observed which caused balistic wave ripples on the water. Then on the bank of the river Viluj a dark mass was observed to fall. The local priest picked it up together with pieces of rock and distributed it.

No. 10. In summer 1912.

Near the river Viluj, at the mouth of its right-hand tributary Batobius, Koutchougouj, Yakoutia, was found a large iron piece (P. L. Dravert "Platinum and its Siberian Beds", Journal "Sibirsky Rassvet", Barnaul, 1919, No. 11-12, p. 99).

No. 11. In 1914.

Beginning of August, on the second terrace of the river Tobol, 7 km. SE, from the town Kurgan, Tcheljabinsk region, there fell in clear weather a longish. egg-shaped stone meteorite (19×9 cm.), which caused, by the air wave, a slight shock to a boy 12 years old. It was kept in the Kurgan Museum. During the years of the Civil War it disappeared (Engineer-Geologist M. M. Vratchinskaya).

No. 12. In 1917.

In the upper part of river Bureya (left tributary of Amur) an iron meteorite of crystalline structure was found, weighing about 2.6 kg., with traces of aerial erosion. The botanist, P. V. Olenin, sent it to the museum of the town Blagoveshtchensk, where it was lost during the years of the Civil War.

No. 13. In 1918.

In the district of Merv, Turkmen S.S.R., fell a large-sized meteorite for which the Tashkent Seismic Station looked in vain in 1937 ("Vestnik Znaniya," 1937, Leningrad, No. 2, 71; "Stalinskaya Molodezh," Kalinin, No. of 1937, March 24; "Izvestiya Zik," No. 130, Aug. 4, 1936).

No. 14. In 1920 or 1921.

At the station Bayan-Aul, Karaganda, Kazakhstan, at the suburbs of the settlement a stone meteorite fell and was carried off somewhere by Kazakhs on horseback, possibly to the moslem mosque (P. L. Dravert, "Leninskoje Znamja," Petropavlovsk, No. 163, July 17, 1937).

No. 15. In 1922.

A stone meteorite fell into one of the villages of the Tara district. The fall was accompanied by detonations, while the sky was clear. *It killed a pig.* It was carried off by a vagabond sorcerer, some of whom were still existing at that time (E. Endukova, 1929).

No. 16. 1924.

First half of August. In the district Bolsheretchenskoye, Omsk region, 5 km. from a small village, a large dark boat-shaped stone meteorite fell, scattering the earth 3-4 paces around, and partly entering the soil. Approximate (evidently exaggerated) dimensions 2.1×0.7×0.5 m. (V. V. Khokhlova).

No. 17. 1925.

Second half of June. In the village Karmanovo, Sargat district, Omsk region, a small (about 2 kg.) stone meteorite broke the roof of the shed in the yard of peasant Koutcherenkin and damaged the foot of his wife, sitting under the shed.* It was roundish in shape and had a smooth dark-reddish crust with protruding spangles of nickel-iron. In 1930 it was taken somewhere by Koutcherenkin ("Mirovedenie", 1935, No. 3, p. 205-206, P. L. Dravert).

No. 18. 1929.

Spring. On the bank of the river Ayova, tributary of the river Osha, falling into Irtysh on the left, in the Rybinskoje district, Omsk region, a peasant dug out a round stone on arable land. It was black on the outside and had not been there in the previous year. Its fate is unknown (P. K. Badaeva, 1931).

No. 19. In 1930.

Near the village Azovo, Azov district, Omsk region, a peasant while ploughing found a meteorite. It was turned over to the teacher Pinegin, who later went away somewhere, taking the meteorite with him (V. Tchernyaev).

No. 20. In 1934.

The geologist, V. G. Vassilyev, found on swampy land a stone meteorite, weighing 10 kg., 40 km. from Skripounovo, right-hand bank of river Ob, Samarovo district, Ostjako-Vogulsk National District. Carrying it with him for a long time, he threw it away, growing tired.

*One of the Grossliebenthal meteorites, which fell in 1881, Nov. 19, wounded a coachman near the station Ssytchevskaya, Odessa district (Prof. R. Prendel, Memoirs of the Novorossijsk Assoc. of Naturalists, Vol. 18, fasc. I).

In giving these data, some of which probably do not appertain to meteorites, the author is following the valuable remark of the academician, V. I. Vernadsky (Essay of Descriptive Mineralogy [in Russian], 2 fasc. I, Petrograd, 1918, p. 109), that it is better to mention a natural phenomenon "than not to point it out, for fear of error; the erroneously indicated one can be verified, but the omitted information opens no course whatever for further work."

Omsk, 1938.

News from the Soviet Union Concerning Meteoric Research

We are greatly indebted to Dr. I. S. Astapowitsch of the Moscow Astronomical Institute for his translation of the two accompanying artic lesby the well-known meteorite expert, Prof. P. L. Dravert of Omsk. The report of the Kazakhstan meteorite, which assumed the shape of an octahedron in its flight through the atmosphere, is of unique interest. Dr. Astapowitsch also sends some interesting details concerning the progress of meteoric astronomy in the Soviet. The meteor expedition to the Crimea in the summer of 1938 (which included G. O. Zateishtchikov and other astronomers) resulted in a series of meteor photographs including material for the determination of two photographic heights. About 400 telescopic observations of meteors were secured at the Tadjik Observatory, Stalinabad, where a regular photographic meteor patrol is also being carried out. The latter programme makes use of 21 cameras, some spectrographic, and others equipped with rotating shutters. A number of meteor photographs have been secured with these instruments. Poor weather conditions were encountered during the maxima of the Perseids, Orionids and Leonids in 1938.

During June–July, 1938, a complete aerial photographic survey of the region of the great Siberian meteorite fall in the Tunguska district was carried out under the direction of Prof. O. J. Schmidt in the Administration of Polar Aviation of the North Sea Way, and at the instigation of Dr. L. A. Kulik. A hydroplane was used in the survey and 1,500 negatives were taken on a scale 1 : 4700, the total area covered being about 240 square kilometres. It is reported that the fallen timbers show up well in the photographs and that two centres of fall are revealed, distant almost a kilometre from each other. The complete report of this survey will be awaited with great interest as it seems fairly certain that the Tunguska fall was an event unique in the history of civilized man.

The activity of the Russian scientists is well demonstrated by the fact that during 1938 five new meteorite falls were recovered in the U.S.S.R. One, on Dec. 2, was a meteorite shower near Odessa. Dr. Astapowitsch promises more details of these falls later. He sends additional data concerning recent Russian falls,

taken from Ac. Sc. U.S.S.R., vol. 20, No. 4, 1938. These descriptions are for meteorites Nos. 30, 31, and 90 in Astapowitsch's list published in the April number of this JOURNAL, 1938, and are reproduced below.

(30)—*Kaïnsaz*, Musljumovskij district, Tartar Autonomous Republic.

$\varphi = 55° 26'$ N.
$\lambda = 32° 55'$ E., Pulkovo.
$T = 1937$, Sept. 13, $11^h 15^m$, U.T.

A fire-ball was observed which left a dust train. The fire-ball fell into fragments during its flight; the detonations were heard at a distance up to 130 km. The meteorites fell on an area 40×7 km., extending SE.–NW. The largest, weighing 102.5 kg., fell in the NW. end; the smallest,—of the size of a nut,—near the village Kosteevo, S.E.; between these: in Kaïnsaz 53 kg., farther on in Tasch-Elga 27.5 kg., Krasnyj Yar 22 kg. and others: a total of 15 fragments weighing over 200 kg. In fracture the meteorites (chondrites) are dark-grey with a greenish tint; on the outside—a black coarse crust with piesoglipts; slightly magnetic. They are in the collection of the Academy of Sciences of the U.S.S.R., Moscow (L. S. Selivanov).

(31)—*Kaptal Aryk*, Kalinin district, Kirguise S.S.R., 70 km. W. from town Frunze

$\varphi = 42° 27'$ N.
$\lambda = 42° 02'$ E., Pulkovo.
$T = 1937$, May 12, $16^h 45^m$, U.T.

The flight (2^s-3^s) of a reddish fire-ball with sparks was observed. It fell in the centre of the village accompanied by a detonation resembling the noise of several airplanes, and by reports heard at about 20-30 km. It fell on the hard soil of the street, digging itself in for 60 cm. A smooth black crust, 0.5 mm. thick, inside close black veins, the fracture—grains of nickel iron. Original weight 3.5 kg. In the collection of the Ac. of Sc. 2904 grams (3 fragments). (D. P. Maljuga).

(90)—*Lawrentjevka*, Orenburg district.

$\varphi = 52° 37'$ N.
$\lambda = 21° 14'$ E., Pulkovo.
$T = 1938$, Jan. 11, $7^h 30^m$, U.T.

It fell 12-20 metres from the hunter, T. A. Zigunov, without light effects (cloudless sky). Before its fall 3 reports were heard at equal intervals; it bored itself for 5 cm. into frozen arable land, without snow cover, scattering clods over 2 m. It was recovered directly after the fall. For 2 minutes it was hot, so that one could not hold it in the hand; after about 10 minutes it cooled. A little piece broke from it at the moment of the fall, then the meteorite itself fell into 3 fragments. The meteorite was lens-shaped, 11 cm.×9 cm.×5 cm. Many chondrite and metal inclusions. Dull blackish smooth crust, without piesoglipts. All 3 fragments weigh 793.62 grams (E. L. Krinov).

The Albedo of Meteorites

In dealing with the whole range of solid matter in space, from particles just a little larger than dust up to objects comparable to asteroids and planets, the reflecting power or albedo of the solid material is of primary importance. Upon this property will depend all estimates of size determined from the observed brightness outside the earth's atmosphere. It is likely that our best knowledge concerning the albedo of asteroids and similar objects can be obtained from a study of freshly broken surfaces of meteorites. Strangely enough, until just recently, very little work in this field has been attempted. Within the last few weeks, however, the writer's attention has been called to two investigations of the reflecting power of meteorites and it seems of value to give a brief review of the results.

The definition of the albedo of an object is considerably more involved than might be supposed and it will be necessary first to consider the exact meaning of the term. Russell has dealt with the subject quite fully in his paper on the albedo of the planets (Ap. J., vol. 43, p. 173, 1916). Lambert was the first to define albedo. If we consider a plane surface exposed to plane parallel light, impinging at angle of incidence i (see Figure 1), then the Lambert albedo L may be defined as the ratio of the total amount of reflected light, integrated over the hemisphere of solid angle, to the total light incident on the surface. For the law of diffuse reflection proposed by Lambert this albedo is independent of i but Seeliger showed that the Lambert law of reflection does not in general hold and that L usually varies with the angle of incidence i. Seeliger proposed the definition that the albedo S should be the mean L for all possible angles i, weighting each L as $\sin i$. The Seeliger albedo has no great practical value and will not be considered further here. Bond proposed the most practical definition from the astronomical standpoint. Suppose a *sphere* is exposed to plane parallel light. Then the Bond albedo B is the ratio of the total amount of light reflected by the sphere in all directions into space to the total amount incident on it. It can be shown that another definition leads also to the Bond albedo. Consider a *plane* surface exposed to incident light coming from all directions (such as diffused sky light). Then the Bond albedo is

the ratio of the total amount of light reflected from the surface to the total amount of light incident on it. An attempt has been made in Figure 1 to illustrate the differences between these definitions. The incident light is represented by full lines, the reflected light by dotted lines. Now, following Russell, we can

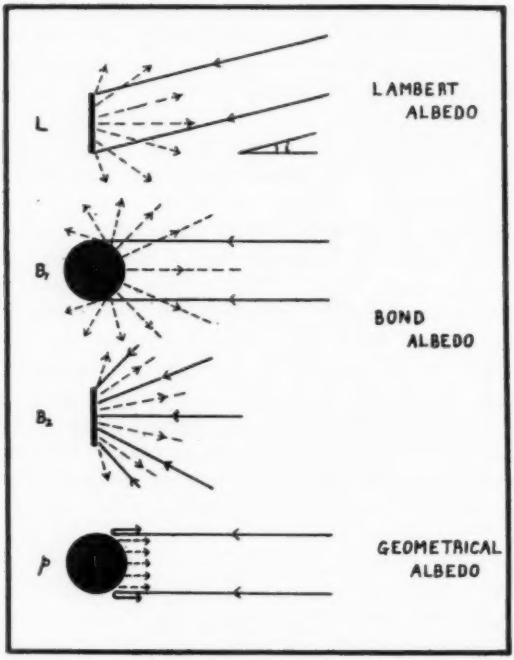

Fig. 1.—A diagrammatic representation of the differences in the various definitions of albedo.

divide the Bond albedo into two parts and write $B = pq$. p is sometimes called the geometrical albedo and depends only on the brightness of a planet at full phase. It may be defined as the ratio of the observed brightness of a planet (or any object) at full phase to the brightness it would have if each part of its surface shone

with an intensity equal to the light incident on it. It may be shown that for any planet

$$p = \frac{R^2 Qd^2}{r^2}$$

where R is the distance of the planet from the sun; r is the radius of the planet; Q is the ratio of apparent brightness of the planet at full phase to the brightness of the sun; and d is the distance of the planet from the earth in units of the sun's distance from the earth. The factor q depends only on the way the light radiated by the planet falls off away from the full phase. Let α equal the angle between the incident and reflected light (at full phase $\alpha = 0$). If $\varphi(\alpha)$ is light reflected by the planet into space at phase angle α and if $\varphi(0) = 1$ then

$$q = 2\int_0^{\pi} \varphi(\alpha) \sin \alpha \, d\alpha \quad .$$

In determining the albedo of the planets there is no difficulty in computing p as it depends on well-known constants, but in most cases we have to make a guess at q since we never observe the great outer planets at a large phase angle and therefore cannot determine $\varphi(\alpha)$ by observation. (For example, we don't know how bright Jupiter looks at the half phase and therefore cannot compute exactly how much light the planet reflects into space at right angles to the direction of the sun.) Russell gives the following values of the Bond albedo for the objects with little or no atmosphere:

	Visual Albedo	*Photographic Albedo*
Mars	.15	.09
Mercury	.06	
Moon	.07	.05
Ceres	.06	
Pallas	.07	
Juno	.12	
Vesta	.26	

Let us now consider our knowledge of the albedo of meteorites. A brief note appeared in 1931 (Schneiderhöhn and Ramdohr, Lehrbuch der Erzmikroskopie, 2, 39, 1931) which stated that a highly polished section of a metallic meteorite (Atacama) reflected

about 60 per cent of the light incident on it with a tendency to make the light a little bluer. A much more detailed study of the Russian meteorite Saratow was published in 1937 by E. L. Krinov (Ast. Jour. of the Soviet Union, vol. 14, p. 356, 1937). The reflection coefficients were studied at various wavelengths by comparison with a gypsum plate as a standard. In diffuse daylight illumination the reflection coefficients at angles of 45 and 70 degrees to the normal averaged .18 and .24 respectively in the wavelength range $\lambda 4000 - \lambda 6500$, the meteorite reflecting very nearly as a gray body. Under direct sunlight reflection coefficients between .22 and .32 were found at an angle 45 degrees to the normal and in the same wavelength range. Low coefficients of reflection (.12 to .20) were found in the region $\lambda 7500$ to $\lambda 8000$. These increased again between $\lambda 8000$ and $\lambda 8500$.

A more comprehensive study of the reflecting power of meteorites has just been completed by Dr. Fletcher Watson of the Harvard Observatory (Proc. Nat. Aca. Sci., vol. 24, p. 532, 1938). Watson studied meteorites in the collection of the Harvard University Museum. He chose seven stones and one iron with nearly flat surfaces which showed little or no effect from terrestrial weathering and rust staining. These specimens were studied in a self-recording spectral-photometer which utilizes what is essentially a photosensitive surface on the inside of a sphere. The sample to be studied is placed over an opening in one side of this sphere directly opposite the incident light which enters from the other side. The reflected light from the meteorite recorded by the photosensitive surface was compared to that from a magnesium oxide surface identically situated in a second photosensitive chamber. The ratio of reflected light to incident light determined in this way is termed the reflectance and Watson suggests that it is comparable to the Bond albedo. Unless the present writer has misinterpreted the method of measurement described it would seem that the reflectance corresponds more nearly to the Lambert albedo at zero angle of incidence since the incident light is normal to the meteorite surface. The Bond albedo can only be determined observationally by studying the diffuse reflection under conditions where the incident light meets the surface at all possible angles.

The eight meteorites studied by Watson are listed below:

Allegan, Michigan	light gray	good surface.
Drake Creek, Nashville, Tenn.	white	some rust stains.
Farmington, Kansas	black	good surface.
Mighei, Ukraine	black	good surface.
Olmedilla de Alarcon, Spain	gray	good surface.
Parnallee, Madras, India	dark gray	many rust stains.
Waconda, Kansas	light gray	few rust stains.
Canyon Diablo, Arizona	iron	surface deeply etched, little specular reflection.

The reflectance ranged from .06 to .33, the meteorites with the best surfaces showing relatively uniform reflectance at various wavelengths. Colour indices determined by comparing reflecting power at λ4360 and λ5510 were positive in all cases but, except for the rust stained samples, were less than 0.2 magnitudes. From an analysis of his results Watson concludes that meteorites are essentially gray bodies with a p or geometrical albedo in the range 0.1 to 0.5 and that irons cannot be distinguished from stones on the basis of colour.

A letter just received from Dr. I. S. Astapowitsch of the Sternberg Institute in Moscow gives the results in brief of a similar investigation carried out by Dr. E. L. Krinov of the Geological Institute of the Academy of Sciences of the Soviet Union. He studied thirteen Russian meteorites, presumably by methods similar to those described in his former paper, referred to above. The list of these meteorites appears below:

13.	(Staroje) Boriskino	black	good surface.
47.	Migei	black	good surface.
28.	Kawkas	black	some rust stains.
73.	Sungatsch	dark	very good surface.
20.	Demina	intermediate	very soiled.
66.	Sawtschenskoje	intermediate	very good surface.
67.	Saratow	intermediate	very good surface.
56.	Ochansk	intermediate	very good surface.
88.	Zigajlovka	white	some rust stains.
43.	Jurtuk (Lubimovka)	white	very good surface.
84.	Wawilovka	white	very good surface.
18.	Brient	white	very good surface.
72.	Staroje Pesjanoje	white	very good surface.

The numbers refer to the list of Russian meteorites published by Astapowitsch in this JOURNAL, vol. 32, p. 195, 1938.

The meteorites seemed to fall into four groups, based on their reflecting power. Mean albedos (probably corresponding most closely to the Bond albedo) were determined for each group at various wavelengths. A summary of these results has been plotted

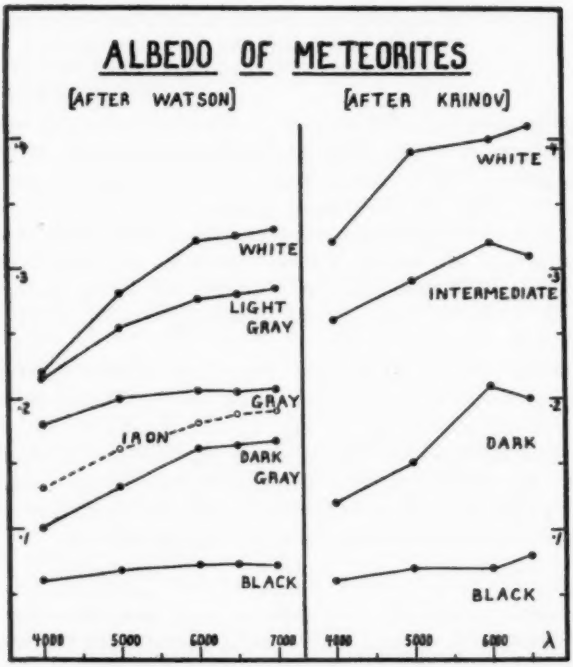

Fig. 2.—A comparison of the reflectances of meteorites as determined by F. Watson with the albedos of meteorites found by E. L. Krinov.

in Figure 2 and for comparison the reflectance, as determined by Watson, was read from his published curves at corresponding wavelengths and plotted on the same scale. It will be seen that there is a very close and satisfactory correspondence between the two sets of values. Krinov's results show a slightly higher relative

reflecting power in the red and this is apparently not owing to oxidation as in general the surfaces he studied were good. It is interesting to note that the range in albedo covered by meteorites corresponds very well with that of the four largest asteroids. It would be surprising, however, if any large asteroid had an average albedo as high as that of the whitest meteorite.

One cannot overemphasize the importance of investigations such as those described above and it is to be hoped that they will prove an incentive to further work of this type. It is particularly desirable to determine both the Bond and geometrical albedos for freshly broken meteorite surfaces by direct observational methods.

South African Meteor Observations, Oct.-Dec., 1938

Mr. Druker of Doornfontein, Johannesburg, continues to send in regular reports of meteor observations. These are particularly valuable as they are made in the southern hemisphere where relatively little meteor research has been carried out. Results for the last three months in 1938 are summarized below. Table I gives the observing periods and total number of meteors observed in each period. The hourly rates tabulated in the last column are

Table I—Meteor Observations in the Transvaal

Date (1938)	S. Afr. S.T.	Total Minutes Observed	Weather Factor	Meteors Observed	Hourly Rate
Oct. 8– 9 . .	9.20– 9.32	12	5	10	50
12–13 . .	8.24– 9.45	21	8	5	14
13–14 . .	7.55– 8.24	29	8	12	25
16–17 . .	7.20– 8.05	32	7–8	5	9
18–19 . .	8.41– 8.59	18	9	2	7
Nov. 20–21 . .	8.50– 9.20	30	6	3	6
Dec. 10–11 . .	8.20– 8.45	25	7	3	7
12–13 . .	9.00–12.15	61	8	11	11
13–14 . .	11.15–11.38	23	8	5	13
14–15 . .	9.25– 9.45	20	7	4	12
17–18 . .	9.25– 9.55	30	9	3	6
Casual observation				6	
		301		69	

uncorrected for weather factor. Mr. Druker plotted the brightest meteors and made all his own records. The high rates near the middle of October are of interest. It will also be noticed that there is an appreciable rise in rates near the Geminid maximum. Table II gives the observed magnitude distribution for all meteors and

TABLE II—MAGNITUDE DISTRIBUTION

−4	−2	−1	0	1	2	3	4	5	6	Total	Mean Mag.
1	2	1	2	4	6	12	29	11	1	69	3.2

TABLE III—COLOUR DISTRIBUTION

r	rw	o	y	yw	w	gy	g
23	2	3	11	1	21	6	2

Table III the colour distribution. The colour abbreviations used refer to the principal colours of the spectrum and are obvious. As is normally the case the red meteors definitely predominate if we except white which generally includes all meteors too faint to show a distinctive colour.

It is encouraging to have these results from South Africa and we hope they will not be the last.

P. M. M.

REVIEW OF PUBLICATIONS

Who's Who in the Moon: notes on the names of all lunar formations adopted in 1935 by the International Astronomical Union. Memoirs of the British Astronomical Association, vol. 34, part 1. Pages 130, 6 x 9½ in., with 2 folding plates. 1938. Price 4*s.* 6*d.*

This is the first memoir of the British Astronomical Association's Historical Section, of which Mrs. John Evershed is director. The introduction gives a historical account of the naming of the lunar formations. The first astronomer to suggest names for the markings seen on the moon was Langrenus of Brussels whose map of the moon was published in 1645. Then came Hevelius of Danzig in 1647. After this was Riccioli of Bologna (1651) whose names are still largely retained. Then followed Schröter (1791 and 1802), Lohrmann (1824), Beer and Mädler (1837), Birt and Lee for the British Association for the Advancement of Science (1865 and 1868), Neison (1876) and Schmidt (1878). In more recent years efforts have been made to secure a generally acceptable list of names by international co-operation. The result was the publication in 1935 for the International Astronomical Union of *Named Lunar Formations: Catalogue and Map* by Mary Blagg and K. Müller. The total number of names is 672, of which 609 are personal names.

In the present publication these names are given in alphabetical order and each is accompanied by a brief note, chiefly biographical. The result is a collection of most interesting details. Any astronomer, professional or amateur, would enjoy this publication and would find it a useful book to have continually on a convenient shelf. The list of contributors contains the names of 28 persons, from various countries, and Mrs. Evershed is to be congratulated on bringing the labours of all to such a happy conclusion. At the end are two plates showing the moon 7½ inches in diameter. One is a reproduction of Riccioli's map (1651); the other is a key map of lunar formations by G. E. Patston (1938).

Three quotations from *Who's Who* will illustrate its nature:

BABBAGE. Charles Babbage, 1792-1871. (B).

The inventor of an analytical calculating machine. He was born at Teignmouth, and as an undergraduate at Cambridge joined John Herschel and Peacock in founding the Analytical Society and introducing into England the notation of the differential calculus. He was one of the founders of the Royal Astronomical Society. 55 Ha

The letter "B" indicates that the name was added by Birt, and "55 Ha" at the end shows where to find the formation on the key map.

IRIDIUM, Sinus. Rainbow Bay. (R) GHb

ZUPUS. Giovanni Battista Zupi, *c.* 1590-*c.* 1650. (R).

Italian Jesuit, long resident in Naples; a friend of Fontana, and observed with him. Riccioli believed that Zupus was the first to see Jupiter's belts, and as he also states that Zucchius saw them in May, 1630, Zupus' discovery must have been in or before that year. He was probably the first also to see the phases of Mercury clearly, in 1639; they had been suspected by Marius, Hortensius, and Galileo. 671 Jg

The letter (R) indicates that Riccioli supplied the name.

C. A. C.

An Introduction to Stellar Structure, by S. Chandrasekhar. Pp. ix + 509, 6¾ × 9½ ins. University of Chicago Press, Chicago, Illinois, 1939. Price $10.00 bound.

This is the second of the series of *Astrophysical Monographs* sponsored by the Astrophysical Journal, edited by Professors Gale, Seares, and Struve. The author, who is well known for his recent and elegant developments in theoretical astrophysics, was formerly Fellow of Trinity College, Cambridge, and is now assistant professor at the Yerkes Observatory.

The book is limited in scope to deal only with the structure of stars which are in equilibrium and in a steady state. Such model stars are, however, treated in considerable detail; and most of the necessary theorems and ideas are gathered together here, and presented in a unified manner.

An excellent brief introduction outlines the material available and sketches the general contents of the book, chapter by chapter. Given the observable mass, radius, and luminosity, and the relations between these, the author states the ultimate objects of the studies as:—

1. To derive the complete march of the physical variables (the density, ρ; the temperature, T; etc.), on the one hand, and the variation of the chemical

composition (the relative abundance of the different elements), on the other, throughout the entire configuration.

2. To describe quantitatively the kind of steady state (radiative, convective, etc.) that exists, eventually as a function of the radius vector, r.

3. To specify the fundamental physical processes that are responsible for the setting up of the steady states described under (2).

4. To evaluate, quantitatively the irreversible processes that must be taking place which should be responsible for the continual loss of energy at the rate L by the star.

Two introductory and two later chapters supply the general physical groundwork, dealing with the development of the laws of thermodynamics, of the general gas laws, the theory of radiation, and the quantum mechanics—all treated rigorously mathematically, but with particular emphasis on those developments most important for astrophysical applications.

The more directly astrophysical chapters deal with the classical theory of polytropic spheres, following Emden's Gaskugeln, gaseous stars and the luminosity formula, and Strömgren's interpretation of the Hertzsprung-Russell diagram on the basis of abundance of the chemical elements. Stellar envelopes and stellar models are discussed at some length. The chapter on quantum mechanics leads to a consideration of degeneracy of gases, and an elucidation of the problem of white dwarfs—a study which has been so greatly advanced by Chandrasekhar's own researches. The final chapter, of a much more speculative nature, deals with nuclear physics and the transmutation of elements as the source of stellar energy. This subject is, of course, in such an active phase of development at the present time that results are very provisional and incomplete.

This book is certain to be an important reference work for theoretical astrophysicists and physicists. It is modern and shows a continuity of thought and of nomenclature that will make it very useful as a text-book for advanced students. The collection of the physical theorems on which the astrophysical deductions are based is a noteworthy feature of the exposition.

The Astrophysical Journal is to be congratulated on the excellence of this volume, which, together with the first monograph by Professor Bok, set a high standard in widely different fields for the following members of the series. F. S. H.

Theoretical Hydrodynamics, by L. M. Milne-Thomson. 552 pages, 6 x 9¾ ins., 4 plates, and 330 text-figures. London and Toronto, Macmillan, 1938. Price $9.50

This book by Professor Milne-Thomson is the first text-book, in English, in which vector methods are used consistently in developing the mathematical theory of fluid motion. Due to his use of vector notation the author has been able to derive in a brief, but clear manner, many results whose derivation is often obscured by the details of the more cumbersome traditional notation used by Lamb and other writers in this field. In dealing with two-dimensional motion the use of complex variable methods is customary and in this book it follows as a natural consequence of the vector method. For the convenience of students who are not familiar with vectors or the theory of functions of a complex variable the author includes in Chapter II a brief but clear account of vector analysis, and in Chapter V a summary of those results in the theory of complex variables which are required in the book. These two chapters tend to make the book more self-contained than other texts in this field and should prove of great assistance to students when reading the remainder of the text. Another noteworthy feature of the book is the fact that the author has been able to illustrate, in an interesting way, the practical significance of many of the theoretical results. Such illustrations add greatly to the reader's interest and give a certain freshness to a subject which is, for the most part, now classical. The exposition is remarkably clear throughout, and the liberal use of formulae and excellent diagrams not only add greatly to the clarity of the argument but also give the book a very pleasing appearance.

The first chapter gives a very interesting account of Bernouilli's theorem and some of its applications to practical problems. This is followed by a systematic account of the motion of a perfect fluid in two and three dimensions including, among others, such topics as vorticity, wave motion, and discontinuous flow. Throughout this account the author places emphasis on those parts of the theory which find application in aerodynamics, and thus we find rather less space devoted to a topic such as wave motion than might be expected from a perusal of other books in the field. In the opinion of many readers it may be felt that the author has given undue prominence to the

theory of discontinuous motion since this subject, while very interesting, is quite difficult and of doubtful importance. Indeed the picture of the wake behind an obstacle, given by this theory, is not altogether correct and the prominence given to this theory may lead students to form an erroneous picture of the flow past an obstacle. The book concludes with a short chapter on viscosity in which the author derives the equations of motion for a viscous liquid and discusses some of their applications. The treatment of viscosity is interesting but unusual. Indeed it seems unnecessarily complicated to think, as Professor Milne-Thomson states, of a fluid element which does not always contain the same fluid particles. In the writer's opinion it would be better to treat stress in a viscous fluid by connecting it with the rate of deformation of a fluid element as in the more usual treatment. Such a treatment would also show the reason why we require the motion of a viscous fluid to satisfy more stringent conditions at the boundaries than we do in the case of a perfect fluid.

B. A. Griffith

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Our Own Island Universe, the Milky Way

The size of our stellar system is a matter of great importance and any estimate made by a competent astronomer arouses much interest. At the recent meeting of the American Astronomical Society at Columbia University, New York City, Director Harlow Shapley discussed this subject and Science Service in *Science* for January 6 gives the following outline of his views:

By study of the useful cluster-type Cepheid variable stars, whose distances can be readily determined, Dr. Shapley found that the globe of stars surrounding the dense disc of the Milky Way is more than 60,000 light-years thick. Dr. Shapley stated that the most distant objects of this globe are farther away than the Magellanic Clouds, our satellite galaxy neighbours. Thus these external systems may, in a tenuous way, be said to lie within the globe of stars that constitute the outer fringes of the Milky Way. Probably 95 per cent. of all known stars, whether variable or not, are within a thousand light-years of the Milky Way plane. But the observed cluster-type variables extend outward from that plane to distances of 50,000 light-years or more. Evidence that the extremely distant Cepheids are part of the Milky Way system lies in the fact that the "population density" of these stars, or the average number of stars per unit volume of space, falls off rapidly at greater distances from the Milky Way.

At a distance of 30,000 light-years from the plane the density is about one-thousandth of that near the plane, Dr. Shapley said. Clearly then the stars are members of our system, and do not represent a random distribution of stars through space.

Dr. Shapley studied the several hundred cluster-type Cepheid variable stars lying in the high galactic latitudes, that is, quite far from the Milky Way plane, and free from the low-lying absorbent clouds which make the measurement of distances difficult. Most of the high latitude stars were found in surveys of faint variables carried on at the Harvard Observatory.

Mathematicians and Poetry

Many mathematicians have made flights into airy verse and some have achieved great fame. For his address on retiring, as chairman of Section L of the American Association for the Advancement of Science, Professor R. C. Archibald of Brown University chose the subject "Mathematicians, and Poetry and Drama". The entire paper is printed in *Science*.

It would seem that Charles Lutwidge Dodgson (1832-1898), better known as Lewis Carroll, is the most famous in this field. He was a mathematical lecturer at Oxford from 1855 to 1881 and was the author of several substantial mathematical publications, but his *Alice's Adventures in Wonderland, Through the Looking Glass* and other such fanciful compositions outshine his other productions. They have been translated into a score of languages.

Another noted mathematician with literary ability as well as prodigious learning was William Whewell (1794-1866), the author of *The History of the Inductive Sciences.* An "accidental" stanza occurs in the chapter on "The Equilibrium of Forces on a Point" in his *Elementary Treatise on Mechanics* (1819), as follows: "Hence no force however great can stretch a cord however fine into a horizontal line which is accurately straight". In a slightly altered form it has been printed as a stanza:

> No power on earth, however great,
> Can pull a string, however fine,
> Into a horizontal line
> That shall be absolutely straight.

An inquiry about the authorship of this verse appeared in the London *Times* in 1935 and it was the subject of an editorial in the *New York Times.*

Whewell was the author of some real poems for one of which, while an undergraduate, he received the Chancellor's medal. He could also produce odd versified puzzles. The following is attributed to him:

> U 0 a 0, but I 0 thee,
> O 0 no 0, but O 0 me;
> Then let not my 0 a 0 go,
> But give 0 0 I 0 thee so.

If this is read, using the word "cipher" for each 0, the interpretation (one can hardly say the meaning!) becomes:

> You sigh for a cipher, but I sigh for thee,
> O sigh for no cipher, but O sigh for me;
> Then let not my sigh for a cipher go,
> But give sigh for sigh, for I sigh for thee so.

Another mathematical genius of last century was James Clerk Maxwell (1831-1879), one of the most profound and original thinkers and the first director of the famous Cavendish Laboratory at Cambridge. Some charming topical verse is found in Lewis Campbell and William Garnett's *Life of Maxwell* (1882).

C. A. C.

A New Comet—Cosik-Peltier.

A new comet has been discovered and reported by two independent observers, the Russian astronomer Cosik, and the American, Peltier. The comet, of eighth magnitude, has been observed at various observatories, and orbits have been computed from short arcs only, by Cunningham, of Harvard, and by Maxwell and Grosch, of Michigan. The elements, which are almost the same for the two computations, are given below (Cunningham):

Elements

Time of perihelion passage, T, - -	1939, Feb. 6., 3904
Argument of perihelion, ω, - - -	168° 21′
Longitude of ascending node, Ω - -	289° 17′
Inclination of the orbit plane, i, - -	63° 15′
Perihelion distance, q, - - - - -	0.71856 ast. units.

These elements indicate that the comet reaches greatest brilliance about February 10, with a probable magnitude of 6.7.

Mr. L. C. Peltier, of Delphos, Ohio, who independently discovered this comet, is a very active amateur observer. He has for years been one of the major contributors of variable star observations to the A.A.V.S.O., has independently discovered two novae, and at least seven comets—for two of which he was sole discoverer.

Correction to January *Journal.*

In the article on Two Inexpensive Drives for Small Telescopes, the diameter of spool D should be given as 2.18 inches (page 10, third line from bottom).

F. S. H.

MEETINGS OF THE SOCIETY

AT TORONTO

December 6, 1938.—The regular meeting was held in the MacLennan Laboratory, University of Toronto, at 8 p.m.

In the absence of the Chairman, Mr. S. C. Brown, Vice-Chairman, presided.

The following were elected members of the Society, Toronto Centre:

Miss Ella Boswell, 9 Lowther Avenue, Toronto.

Mr. H. B. Scandrett, 64 Bernard Avenue, Toronto.

Mrs. H. B. Scandrett, 64 Bernard Avenue, Toronto.

Mr. Donald C. Gow, Bartlett, MacDonald & Gow, Windsor, Ont.

Miss Pauline Drutz, 106 Euclid Avenue, Toronto.

Mr. Albert J. Cater, 20 McMaster Avenue, Toronto.

Miss Widmer Brough, 4 Harper Gardens, Toronto.

Prof. Kenneth B. Jackson, Engineering Building, University of Toronto.

Mr. W. G. Pierdon, 35 Langley Avenue, Toronto, was proposed for membership, recommended by Mr. F. K. Dalton; as it was the last meeting of the year it was agreed that the usual delay be waived, and that Mr. Pierdon be elected a Member of the Society, Toronto Centre.

The main lecture of the evening—"Progress on the 200-inch Telescope"—was given by Mr. G. H. Tidy, B.A. An interesting account of the site and construction of this great telescope was illustrated by slides made from photographs taken recently. The movable parts are now well in place. Four tons of glass had to be ground out of the disc to a depth of four inches. It will be two years yet before the mirror will be ready.

Dr. P. M. Millman continued his course with a short lecture on "Cosmic Action", likening action in the cosmos to a great game which begins and ends in the unknown. We have a very imperfect knowledge of the pieces and the board on which it is played, and we know still less about the rules of the game. Only by a continued observance of all the moves that are made can we hope to come to a better understanding of its progress. Representative pieces were named—electron, proton, neutron and the others, with the mass and charge of each. Next came the fundamental properties of the pieces of the board, followed by the rules of the game—gravitation, electrostatic forces, magnetic forces, radiation pressure, kinetic energy, etc., and finally the observed moves of the various pieces and the effects produced.

Appreciation of both lectures was expressed by Mr. J. R. Collins. Mr. A. R. Hassard also contributed to the discussion.

D. W. Best, *Recorder.*

AT VANCOUVER

October 11, 1938.—The 57th regular meeting of the Vancouver Centre of the Royal Astronomical Society of Canada was held in Room 200, Science Building, University of British Columbia, at 8 p.m., with an attendance of about 80.

Motion pictures were shown on "The Birth of the Earth", "Hello Mars", and "Through the Center of the Earth". These films, from the General Film Co., of Regina, were not satisfactory.

The president, Mrs. Laura Anderson, spoke briefly about the work of the Centre.

Dr. Shrum then exhibited some films recently taken of the University and its activities.

November 8, 1938.—The 58th regular meeting of the Vancouver Centre was held at 8 p.m., Tuesday, November 8, 1938, in Room 200, Science Building, University of British Columbia. There was a large attendance.

After the meeting was called to order by the President, the Secretary read the minutes of the April, May, and October meetings. These minutes were adopted as read. At the request of the council, and for the information of all Vancouver Centre members, the Secretary then read the minutes of the General Council Meeting at Toronto on March 4, 1938.

The President then called upon Dr. E. O. Anderson, of the Physics Department of the University of British Columbia, to introduce the speaker of the evening, Dr. Andrew McKellar, since 1935 a member of the staff of the Dominion Astrophysical Observatory at Victoria.

Dr. McKellar's address on "Astronomical Motion Pictures", was divided into four sections, consisting of:

1. A brief history of the McMath-Hulbert Observatory, which has pioneered in the taking of motion pictures of solar prominences.
2. A description of the equipment at this observatory, and of the way it is used.
3. A summary of previous observation and knowledge of solar prominences, together with some remarks on their significance.
4. A 12-minute showing of motion pictures of solar prominences, and of adjustments being made in the solar tower equipment, taken at the observatory mentioned.

At the outset, Dr. McKellar emphasized the importance of the McMaths' contribution to astronomy in developing the "McMath drive", for keeping a telescope centred on an apparently moving celestial object, especially with the accuracy required for motion picture work. He also stressed the value of the motion picture as a tool of instruction in astronomy. Incidentally, he described its use in research on land contours in lunar craters, by studies of the velocities of the edge of the shadow of the crater rim, across the floor of the crater, due to the moon's rotation.

The description of the Solar Tower and its equipment at the McMath-Hulbert Observatory was well illustrated with slides.

Reference was made to Professor Pettit's classification of solar prominences, and much information was given both verbally and by slides, concerning: frequency of occurrence, dimensions, velocities, direction of motion, vortex action, etc.

The very excellent motion pictures which were then shown revealed several very excellent features of prominences, notably:

1. The predominence of inward motion of matter toward the sun.
2. Surges of matter out and back, occupying various periods of time, but many of about ten minutes' duration.
3. Coronal streamers shooting inward for great distances.

In conclusion, Dr. McKellar mentioned the work of Lyot, at Pic du Midi, in France, in taking excellent photographs using filters only and no spectrograph for the selection of the wave lengths to be used.

The questions and discussion that followed made it evident that the lecture had aroused much interest, both in solar prominences, and in this modern way of studying them.

December 13, 1938.—The 59th regular meeting (the eighth annual meeting) of the Vancouver Centre was held at 8.15 p.m., Tuesday, December 13, 1938, in Room 200, Science Building, University of British Columbia. Mrs. Laura Anderson, the President, was in the chair.

The secretary read his report of the year's activities.

The treasurer read a report of the year's receipts and expenditures, and a statement of the present financial position of the centre.

The 1939 council of the Vancouver Centre was then elected, all the council's nominees being chosen by acclamation, as no other nominations were made from the floor. Motions for the closing of nominations for the respective officers were made and seconded as follows, all being carried unanimously:

Honorary Pres.—Dean Daniel Buchanan.
President—Mr. C. A. McDonald.
1st Vice-Pres.—Mr. C. E. Bastin.
2nd Vice-Pres.—Mr. D. L. Shaw.
Secretary—Dr. A. M. Crooker.
Treasurer—Dr. H. D. Smith.
Council—Mrs. Laura Anderson, Mr. J. C. Jorgenson, Mr. H. P. Newton, Mrs. C. A. Rogers, Mr. F. R. Stewart, Mr. J. Teasdale, Mr. E. C. Thrupp, Dr. Wm. Ure.

The President then called upon the President-elect, Mr. C. A. McDonald, to give the address of the evening on "Modern Methods of Determining Time and Geographical Position".

As methods of time determination have changed but little during the past twenty years, Mr. McDonald made only passing reference to this. Two points of historical interest were mentioned, however, first, the now out-of-date

method of "clearing" discrepancies between the predicted and actual positions of the moon with respect to certain stars, as calculated from the data of the British Nautical Almanac, and second, the old custom of dividing the periods of daylight and darkness into twelve hours each, regardless of their actual length.

The chief advance, Mr. McDonald pointed out, is in the use of radio for informing people everywhere of the correct time at Greenwich.

Illustrating his remarks by numerous blackboard diagrams, of the type used by navigators, Mr. McDonald then discussed various methods of determining position. These included:

For latitude: observation of the meridian altitude of the sun,
ex-meridian observations,
observations of the altitude of Polaris.

For complete position: by the Sumner position line in combination with various other data, for instance:
another intersecting position line,
a radio-beacon compass bearing,
a set of soundings, fitted on the position line or on a line parallel to it on the chart.

The speaker dwelt at some length on the discovery and use of the Sumner position line. He pointed out that it is a small arc of a circle of equal altitude of a celestial object, but of negligible curvature in the comparatively short distances for which it is useful. The St. Hilaire method of determining position by means of pre-calculated intersecting position lines was described and explained.

In closing, Mr. McDonald described the method used in coastal waters of determining position by the aid of synchronized fog horn and radio signals, direction being determined by the ship's direction-finding radio receiver, and the distance from the source by calculation based on the corrected velocity of sound and the time interval elapsing between the receiving of radio and sound impulses which left the source simultaneously.

The President expressed the thanks of the Centre to Mr. McDonald for his interesting and informative address. Dr. G. M. Shrum then moved a vote of thanks to the retiring officers and council for their work during 1938.

H. W. Fowler, *Secretary.*

January 10, 1939.—The fifty-ninth regular meeting of the Vancouver centre was held at 8.15 p.m. in the Science Building of the University of British Columbia.

The newly-elected president, Mr. C. A. McDonald, was in the chair and introduced the speaker of the evening, Dr. Harold D. Smith of the Physics Department of the University of British Columbia. Dr. Smith spoke on "Low Temperatures" dealing with the production, properties and uses of solid carbon dioxide, known in the trade as "dry ice". This substance is produced by purifying and later condensing the flue gases obtained by burning high grade

coke under forced draft. Only about 40% of the carbon dioxide is recovered but the energy needed for operating the plant is obtained from the heat of combustion of the coke.

Solid carbon dioxide is used extensively in the soda-water industry, in refrigeration of perishables and in the production of shrink fits in the automotive industry. Within fifteen years its uses have doubled many times from the original use of curing warts, so that to-day it is an indispensable article of commerce with over four hundred uses.

An interesting engineering application was described by Dr. Smith in which a freezing mixture of "dry ice" in alcohol was used to cool and contract the forty ton shaft, and so separate it from the two hundred and seventy ton rotor of a generator unit at the Ontario Hydro Electric Power plant at Queenston. The suggestion was made that such a procedure might be useful in the construction of shrink fits in large astronomical telescope mountings.

The informal discussion following the address was widely entered into by the members. Mr. McDonald expressed to the speaker the warm appreciation of the meeting.

A. M. CROOKER, *Secretary.*

AT EDMONTON

October 13, 1938.—Mr. W. E. Mjolsness spoke on "The Telescope", describing its historical development from the beginning of the 17th century, the fundamental principles of refracting and reflecting telescopes, with their respective advantages and disadvantages, and the new process of aluminizing mirrors. He mentioned various types of mounting, and showed a number of illustrative diagrams and pictures. Finally he described briefly from his own experience the operations involved in grinding, polishing, and testing a home-made mirror.

October 27, 1938.—A special open meeting, attended by some 150 people, was held to witness a film on "Solar Prominences" taken at the McMath-Hulbert Observatory, Michigan. Dr. Campbell gave an introductory explanatory talk, illustrated by slides and lecture-bench demonstration, the essential principle of the spectroheliograph, and described from personal knowledge the nature of the work going on at the McMath-Hulbert Observatory. The film, prepared by Dr. Pettit, showing the apparatus used and different types of prominences observed, gave a vivid impression of the mighty storms always in progress on the surface of the sun.

After some questions and discussion, the film was run through a second time, to give members a chance to note particular points they might have missed.

November 10, 1938.—Dr. E. H. Gowan spoke on "Variable Stars", describing the methods of measuring the variability of stars, visual, photographic and bolometric, and the kind of results obtained. He divided the variable stars into three main classes, those with regular period, those with irregular period, and

novae. The main part of the talk was concerned with the eclipsing binaries, and the production of various types of light curve was explained with the help of models, diagrams and slides. The remarkable Cepheid variables were also briefly described, as well as the enormous changes of brightness occasionally observed in novae.

December 8, 1938.—At the annual meeting the principal after-dinner speaker was Professor C. S. Burgess, Professor of Architecture in the University of Alberta, who read an interesting and witty paper on the influence of astronomy on the thoughts and actions of the man in the street. He referred briefly to the astrological ideas of earlier times, some of which still linger, and to the sense of beauty awakened by the spectacle of the starry heavens. He described the great revolution in human thought caused by the discovery of the roundness of the earth, and the somewhat similar revolution in more modern times caused by the discovery of the vast scale of the Universe. He pointed out, however, that the real cause for wonder is not the insignificance of man, but the power of the human mind to penetrate these immensities. Mr. Burgess considered that the reign of natural law had been over-emphasized, and that modern science generally, whatever changes it had produced in our mental attitudes, had failed to develop the more important knowledge of truth, beauty and right conduct.

E. S. KEEPING, *Honorary Secretary.*

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